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REPELLENCY OF METHYL ANTHRANILATE TO PRE-EXPOSED AND NAIVE CANADA GEESE

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Abstract: To improve our understanding of the effectiveness of avian feeding repellents, we evaluated whether Canada geese (*Branta canadensis*) exhibited learned avoidance of ReJeX-iT AG-36 (AG-36), a methyl anthranilate (MA) formulation containing 14.5% MA (vol/vol). During 2 experiments in August-September 1995, we pre-exposed geese orally to 0.0, 1.3, or 4.0 g AG-36 and released them onto 10- × 10-m grass plots treated with AG-36 at rates of 22.6 and 67.8 kg/ha. Mean numbers of bill contacts and mean numbers of geese observed on control and treated plots were similar ($P \geq 0.21$) for geese pre-exposed or naive to AG-36. Overall, mean numbers of bill contacts and mean numbers of geese also were similar ($P \geq 0.56$) on control and treated plots. Mean mass of droppings on control and treated plots was similar ($P > 0.99$) during the experiment with 22.6 kg/ha AG-36 but was greater ($P = 0.01$) on control plots during the experiment with 67.8 kg/ha AG-36. We conclude that learned avoidance of AG-36 by Canada geese pre-exposed orally to 1.3 or 4.6 g AG-36 did not occur and that AG-36 applied to turf in enclosures at rates of 22.6 and 67.8 kg/ha was not effective as a grazing repellent for geese.

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Increases in nonmigratory Canada goose populations in North America have resulted in an increase in goose/human conflicts. Geese feeding on agricultural crops and turf has caused severe localized economic loss (Hunt 1984, Kahl and Samson 1984, Conover and Chasko 1985, Conover 1988). High concentrations of goose feces in urban settings (e.g., golf courses) have resulted in reduced aesthetic and recreational value (Conover and Chasko 1985). Although various mechanical frightening and harassment devices have been employed in efforts to alleviate these conflicts (Marsh et al. 1991, Cleary 1994), few chemical repellents have recently been evaluated as potential deterrents.

One repellent recently registered by the U.S. Environmental Protection Agency that has been evaluated for bird management is MA (Mason et al. 1991, Dolbeer et al. 1992, 1993; Avery et al. 1995, Belant et al. 1995). Several studies have assessed the effectiveness of MA formulations as avian feeding deterrents (Cummings et al. 1991, 1992, 1995; Avery et al. 1995). No study, however, has directly compared the repellency of MA to geese naive or pre-exposed to this chemical to determine if learned avoidance occurs. Learned avoidance of a repellent would be advantageous, potentially reducing bird use of a location treated with the repellent for a longer period of time than the repellent is actually present. Our objective was to determine whether repellency of AG-36 applied to turf differs between Canada geese pre-exposed or naive to AG-36.

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METHODS

Canada geese of undetermined sex were captured during molt in northern Ohio during June 1995 and transported to a 2-ha fenced pond in Erie County. Grass and shade were available along the perimeter of the pond. Geese had primaries from 1 wing plucked before being released into this pond. Cracked- or whole-kernel corn was provided as a food supplement. A 0.4-ha fenced holding area adjacent to the pond was used to separate experimental from non-experimental geese. This holding area contained grass, shade, and included about 20 m^2 of the pond. Geese maintained in this area were also provided corn.

A 25-m fenced chute connected the holding area to the test site which consisted of 4 10- × 21-m pens constructed of 1.5-m fence in a grass area. Pens were separated by ≥2 m. Each pen consisted of 2 10- × 10-m plots (treatment and control) separated by a 1-m wide buffer of grass which was delineated with spray paint. Two 0.5-m diameter pans of water were located within each buffer area. The grass in each pen was mowed just before treatment and about every 7 days thereafter. A rain gauge was placed at the test site to monitor precipitation.

Experiment 1

Before pretreatment conditioning, 24 geese were herded from the pond facility to the holding area and each was assigned randomly to 1 of 2 groups of 12 geese. We attached consecutively numbered, color-coded neck collars (1 color/group) to individuals in each group. For 7 consecutive days before testing, the same 24 neck-collared geese were herded from the holding area to the test site and the same 6 geese (3 from each group) were placed in each of the 4 pens at 0900 hours and allowed to graze until 1600 hours when they were herded back to the holding area. This grazing schedule allowed geese to adjust to pen conditions and establish social hierarchies before testing.

To evaluate the repellency of AG-36 between pre-exposed and naive geese, the 12 individuals from a randomly selected group were sprayed orally with 1.3 g AG-36 with MA (14.5% vol/vol) on the day before testing. Remaining geese served as controls and were sprayed with 1.3 g of AG-36 without MA. The bill of each goose was held open manually and the nozzle of the hand-held atomizer was positioned to spray AG-36 directly into the mouth and throat. We determined that 1.3 g AG-36 was the maximum amount a captive goose could ingest in 1 day (14 hr) if it foraged exclusively on turf treated with AG-36 at the manufacturer recommended rate (22.6 kg/ha). We estimated ingestion rates before pretreatment by calculating the mean number of grass stems consumed from 100 bill contacts and the mean number of bill contacts/hour from 4 1-hour observations. We also estimated the mean number of grass stems/plot by counting stems in 1 randomly selected 100-cm^2 area from each plot. We then determined the mean area of grass consumed/goose/day, and using an application rate of 22.6 kg/ha, estimated the maximum amount of AG-36 a goose could ingest.

Immediately following goose pre-exposure, grass in the pens was mowed to a height of 5 cm and 1 plot in each pen was selected randomly as a control. We mixed AG-36 (without MA) with water and using a wand-type sprayer with motorized pump and agitator, evenly applied the formulation on control plots at a rate of 22.6 kg/ha. Remaining plots were then similarly treated with AG-36 (containing MA) at a rate of 22.6 kg/ha. We sprayed AG-36 without MA initially to avoid contamination of control plots and also to provide a direct evaluation of the repellency of MA.

The day following goose and plot treatments, 2 individuals in a vehicle near the pens conducted observations of geese. Vehicles had been positioned near the pens frequently during pretreatment to ensure their presence did not modify goose behavior. Observations occurred daily for 2 hours, beginning immediately after geese were released into the pens. Each individual observed 1 group of 3 geese in each of 2 pens for 1 hour, alternating observations between pens every 60 seconds (daily total of 30 min/group/pen). During each 60-second interval, observers recorded the number of geese observed initially in each plot, and the total number of bill contacts with grass in each plot. Observations of geese were then conducted similarly in the 2 remaining pens. We alternated pairs of pens observed initially among days such that geese were observed equally during the 2 1-hour observation periods.

To estimate fecal mass on each plot, we established 2 1-m wide transects between diagonally opposing corners. We collected feces daily at 1600 hour from each plot during the treatment period. Feces were then placed in a drying room at 38 C for 48 hours before weighing. Fecal mass was converted to g/plot for each plot by day of collection before analysis.

Mean numbers of geese observed and mean numbers of bill contacts on each plot were determined and compared between and within goose pre-exposure and plot treatments with crossed, randomized block (pens) analysis of variance (ANOVA) with repeated measures (days) (Zar 1984, SAS Instit. Inc. 1988). Mean mass of fecal material collected was analyzed using randomized block ANOVA with repeated measures. If main effects or interactions were significant ($P < 0.05$), we used Tukey tests to determine which means differed.

Experiment 2

We began herding 24 experimentally-naive geese into pens for pretreatment conditioning 19 days after the conclusion of experiment 1. Experiment 2 was conducted identically to experiment 1 except that goose groups (pre-exposed and naive) were sprayed orally with 4.0 g of AG-36 and treatment and control plots were sprayed with AG-36 (with and without MA, respectively) at 3 times the manufacturer recommended rate (67.8 kg/ha).

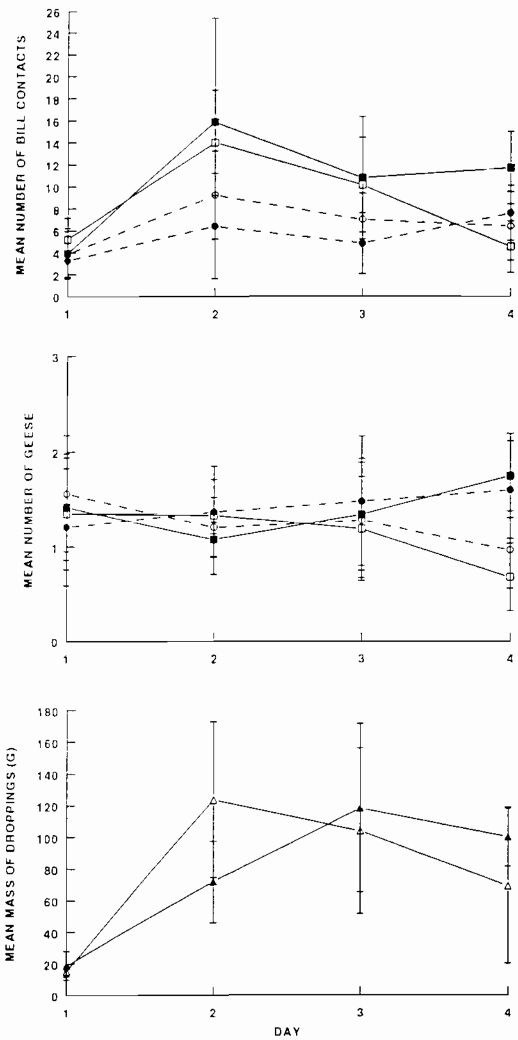

Fig. 1. Mean number of bill contacts/3 Canada geese/minute, number of geese/observation, and fecal mass/0.01 ha/7 hours on grass plots treated with ReJeX-iT AG-36 (AG-36) (shaded symbols) at an application rate of 22.6 kg/ha, and on control plots (open symbols), Sandusky, Ohio, August 1995. Circles and squares represent geese naive and pre-exposed to AG-36, respectively; triangles represent both naive and pre-exposed geese. Capped vertical lines represent 1 standard error.

RESULTS

Experiment 1

There was no difference ($F = 0.04$, 1,12 df, $P = 0.85$) in the overall mean (± SE) number of bill contacts observed on control (7.6 ± 1.2/min) and treated plots (8.1 ± 1.6/min) (Fig. 1). Similarly, the mean number of bill contacts by pre-exposed (6.1 ± 1.0/min) and naive geese (9.5 ± 1.7/min) did not differ ($F = 1.74$, 1,12 df, $P = 0.21$). There was no interaction ($F = 0.38$, 1,12 df, $P = 0.55$) between plot treatments and goose pre-exposure treatments. The number of bill contacts was similar among days ($F = 2.79$, 3,36 df, $P = 0.05$). Interactions of day with plot treatment, goose pre-exposure, or plot treatment-goose pre-exposure did not occur ($F = 0.16$–0.67, 3,36 df, $P \geq 0.50$).

Mean numbers of geese/observation on treated (1.4 ± 0.2) and control (1.2 ± 0.2) plots was similar ($F = 0.30$, 1,12 df, $P = 0.60$). The mean number of pre-exposed (1.3 ± 0.2) and naive (1.3 ± 0.2) geese present/observation on treated and control plots also was similar ($F = 0.02$, 1,12 df, $P = 0.90$). There was no day effect ($F = 0.12$, 3,36 df, $P = 0.95$) and no interactions ($F = 0.02$–1.33, 3,36 df, $P \geq 0.28$) of day with plot treatment, goose pre-exposure, or plot treatment-goose pre-exposure.

Mean fecal mass (g/0.01 ha/7 hr) collected on control (19.7 ± 5.6) and treated (19.6 ± 4.3) plots was similar ($F = 0.00$, 1,6 df, $P > 0.99$). There was no day effect ($F = 2.75$, 3,18 df, P

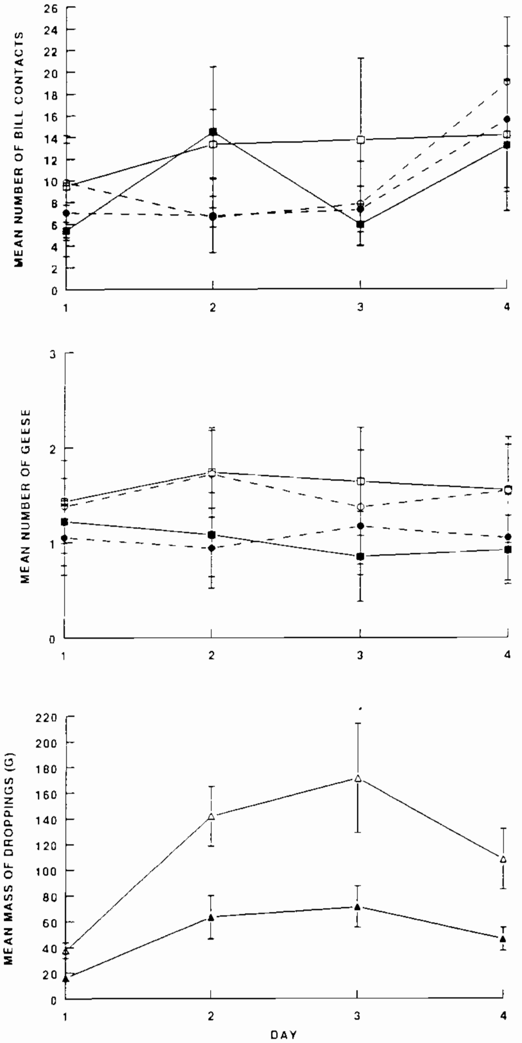

Fig. 2. Mean number of bill contacts/3 Canada geese/minute, number of geese/observation, and fecal mass/0.01 ha/7 hours on grass plots treated with ReJeX-iT AG-36 (AG-36) (shaded symbols) at an application rate of 67.8 kg/ha, and on control plots (open symbols), Sandusky, Ohio, September 1995. Circles and squares represent geese naive and pre-exposed to AG-36, respectively; triangles represent both naive and pre-exposed geese. Capped vertical lines represent 1 standard error.

= 0.10) or day-plot treatment interaction (F = 0.50, 3,18 df, P = 0.68) for fecal mass.

We recorded 0.0, <0.5, 22.0, and 0.5 mm of rain on days 1, 2, 3, and 4 of observations.

Experiment 2

One goose (naive group) escaped from the holding area following pre-exposure treatment and before observations on day 1. This goose was recaptured and placed with its group before observations on day 2. Thus, bill contacts and presence by plot for naive geese in 1 pen was weighted proportionally on day 1, by observations from the 2 naive geese present. Fecal mass from this pen also was weighted proportionally for treated and control plots, with data from 5 of 6 geese present.

The overall mean number of bill contacts observed on treated (9.5 ± 1.5/min) and control (11.8 ± 1.6/min) plots was similar (F = 0.37, 1,12 df, P = 0.56) (Fig. 2). The mean number of bill contacts by pre-exposed (11.2 ± 1.7/min) and naive (10.0 ± 1.5/min) geese also was similar (F = 0.11, 1,12 df, P = 0.75). There was no interaction (F = 0.03, 1,12 df, P = 0.87) between plot treatments and goose pre-exposure treatments. There was a day effect (F < 0.00, 3,36 df, P < 0.01) with more (P < 0.05) bill contacts observed on day 4 than on days 1–3. There were no interactions (F = 0.55–2.63, 3,36 df, $P \geq$ 0.06) of day with plot treatment, goose pre-exposure, or plot treatment-goose pre-exposure.

There was no difference (F = 1.35, 1,12 df, P = 0.27) in the total mean number of geese/observation on treated (1.0 ± 0.1) and control (1.5 ± 0.2) plots. Overall mean presence of pre-exposed (1.3 ± 0.2) and naive (1.3 ± 0.2) geese/observation on treated and control plots also was similar (F < 0.01, 1,12 df, P = 0.95). There was no interaction (F = 0.02, 1,12 df, P = 0.89) between plot treatment and goose pre-exposure treatment. There was no day effect (F = 0.26, 3,36 df, P = 0.79) and no interactions (F = 0.15–0.75, 3,36 df, $P \geq$ 0.53) of day with plot treatment, goose pre-exposure, or plot treatment-goose pre-exposure.

Mean fecal mass (g/0.01 ha/7 hr) was greater (F = 11.83, 1,6 df, P = 0.01) on control (114.8 ± 17.7) plots than on treated (49.3 ± 7.8) plots. There was a day effect (F = 9.57, 3,18 df, P < 0.01), with less (P < 0.05) fecal mass collected on day 1 (27.0 ± 5.1 g) than on days 2–4 (77.2 ± 16.5–121.4 ± 28 g). There was no day-plot treatment interaction (F = 1.59, 3,18 df, P = 0.23) for fecal mass.

We recorded 0.0, 0.0, 9.0, and 0.8 mm of rain on days 1, 2, 3, and 4 of observations.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Geese in this study did not exhibit learned avoidance of AG-36 on turf when pre-exposed orally to this formulation. Learned avoidance of a repellent would be beneficial, potentially reducing bird use of a location treated with the repellent for a longer period of time than the repellent is actually present. Mason et al. (1989) determined that avoidance of MA compounds occurs through various nerve receptors (e.g., trigeminal, taste, odor). These receptor systems in geese were undoubtedly affected during oral spraying with AG-36. Cummings et al. (1995) stated that learned avoidance of MA formulations does not occur, whereas Glahn et al. (1989) stated that European starlings (*Sturnus vulgaris*) may have exhibited avoidance of livestock feed treated with dimethyl anthranilate. These studies, however, did not directly compare the repellency of birds naive or pre-exposed to the formulations used. Recently, trigeminal repellents (including MA) have been determined ineffective in causing learned odor avoidance in starlings (Clark 1996). Additional research is required to determine whether learned avoidance of MA compounds occurs in other bird species and if so, which sensory receptors are involved in mediating this response.

Our experiments showed no evidence that AG-36 was effective as a grazing repellent for geese when applied to turf in enclosures at rates of 22.6 and 67.8 kg/ha. Mean fecal mass was less in treated than in control plots in experiment 2, when the application rate (67.8 kg/ha) was 3 times the manufacturer recommended rate, but we measured no difference in feeding rates or numbers of geese between treated and control plots. As AG-36 currently contains a binding agent, rainfall that occurred during these 2 experiments should not have affected its retention by grass and consequently reduced its effectiveness (P. F. Vogt, pers. commun.). This is supported from our study by no significant interactions of day with plot treatments. In contrast, Cummings et al. (1995) found that mean numbers of geese and mean mass of droppings were less on grass plots treated with AG-36 at a rate of 59 kg/ha than on control plots for ≤4 days.

The ineffectiveness of AG-36 demonstrated in our study may have been influenced in part by using captive geese. Captive geese had limited access to untreated areas relative to free-ranging geese. Thus, AG-36 may be more effective in repelling free-ranging geese, particularly when combined with other forms of harassment. Also, the disparity of results in experiment 2 demonstrate the importance of using >1 measure of aversion for assessing the effectiveness of feeding repellents. Data should include at least 1 direct measure of feeding aversion (e.g., food consumption, grazing rate). Nonetheless, similarity of grazing rates and goose presence between treated and control plots and goose pre-exposure treatments in our study suggest overall ineffectiveness of AG-36 as a grazing repellent.

Higher concentrations of MA appear necessary to deter birds from food than from water (Cummings et al. 1992, Dolbeer et al. 1993, Belant et al. 1995). Rogers (1978) stated the effectiveness of repellents may depend on the material being protected (e.g., food vs. water). Water may also be a more effective carrier of MA to trigeminal receptors than is food, resulting in increased detection and repellency. Inter- and intraspecific taste sensitivity has been documented for other avian species (Espaillat and Mason 1990).

Because aversion to MA-treated food has been demonstrated previously with several avian species, including Canada geese (Mason et al. 1989, Avery et al. 1995, Cummings et al. 1995), application rates greater than those used in this study may repel geese from turf. At current retail prices, applying AG-36 to turf at a rate of 67.8 kg/ha would cost $870/ha. This cost is 14.5 times greater than the amount ($60/ha) turf managers are willing to spend for a goose grazing repellent (Otis et al. 1989). Thus, even if AG-36 was effective as a grazing repellent at application rates >67.8 kg/ha, its use on turf likely would be cost prohibitive.

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